CLINICAL SIGNIFICANCE OF INTRAVENTRICULAR BLOCK IN ACUTE MYOCARDIAL INFARCTION*

RICHARD J. STOCK, M.D.

Assistant Clinical Professor of Medicine
Columbia University College of Physicians and Surgeons
New York, N. Y.

It is my purpose to discuss some observations on a small group of patients with acute myocardial infarction who develop intraventricular blocks and frequently experience cardiac arrest due to complete heart block. Successful resuscitation in this circumstance is often not possible because the rapidity of the course does not allow time for artificial pacing. The identification of these patients before complete heart block develops is critical for successful treatment and depends upon the recognition of certain specific electrocardiographic patterns of intraventricular block. I shall try to focus my discussion on three aspects of this clinical problem: 1) the electrocardiographic findings that signal impending complete heart block, 2) the methods of electrocardiographic scanning that best detect these signs, and 3) the clinical differences that exist among patients with variations in this electrocardiographic pattern.

PATTERNS OF INCOMPLETE A-V BLOCK THAT LEAD TO COMPLETE HEART BLOCK

My discussion concerns 350 consecutive patients with acute myocardial infarction who were screened for A-V block, bundle-branch block, and combined right bundle-branch block with either left anterior or left posterior hemiblock, as defined by Rosenbaum.[1] The criteria for selection of patients and the methods for collecting data employed in studying this series have already been reported.[2] The follow-up period since the initial hospitalization for myocardial infarction now ranges from three to six years.

Table I indicates that complete heart block was observed in 24 patients, or 7%. Approximately half of the patients with complete heart

*Presented at a *Conference on Heart Block: Clinical and Physiological Considerations* held by the New York Heart Association at The Waldorf-Astoria, New York, N. Y., January 26, 1971.

TABLE I. SITE OF MYOCARDIAL INFARCTION IN 24 PATIENTS WITH COMPLETE HEART BLOCK

	Number of patients
Acute inferior	11
Acute inferior, old anteroseptal	2
Unknown	2
Acute anteroseptal	6
Acute anteroseptal, old inferior	2
Acute posteroseptal, subacute inferior	1

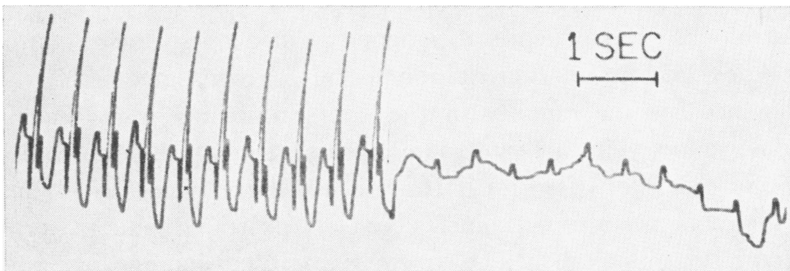

Fig. 1. The sudden development of fatal complete heart block in a patient with acute anteroseptal myocardial infarction. The recording speed was 10 mm./sec.

block had acute inferior myocardial infarction either occurring alone or superimposed on an old anteroseptal infarction. The events that lead to the development of complete heart block in inferior myocardial infarction have been described by many previous investigators[3-8] and need no further amplification on this occasion.

Instead I should like to draw your attention to the eight patients with acute anteroseptal infarction and complete heart block, two of whom had sustained earlier inferior myocardial infarctions. This study was prompted by observations in one of these patients, who abruptly experienced cardiac arrest due to complete heart block from which resuscitation was not possible (Figure 1). There were no antecedent dropped ventricular beats in this patient, and the PR interval did not increase. When the continuously recorded electrocardiographic records of all eight patients with anteroseptal infarction were analyzed (Table II), complete heart block was found to develop abruptly in five without

TABLE II.* ELECTROCARDIOGRAPHIC PATTERNS IN ACUTE ANTEROSEPTAL MYOCARDIAL INFARCTION WITH COMPLETE HEART BLOCK

	Number of patients
RBBB, LAH, QV 1-4	3
RBBB, LPH, QV 1-4	3
Unknown	2

*Abbreviations: RBBB = right bundle-branch block; LBBB = left bundle-branch block; LAH = left anterior hemiblock; LPH = left posterior hemiblock; Q V 1-4 = Q waves present in leads V-1 through V-4.

prior incomplete A-V block to signal a warning. There were only three instances of Mobitz type II second-degree A-V block and no instances of the Wenckebach phenomenon or prolongation of the PR interval. These observations suggest that the placing of a prophylactic endocardial pacing electrode in anteroseptal myocardial infarction should not depend on the appearance of Mobitz type II second-degree A-V block, which appears in a minority of the patients who develop complete heart block. The majority develop complete heart block abruptly without transition through a stage of incomplete heart block.

Patterns of Intraventricular Block That Lead to Complete Heart Block

In this setting the construction of criteria for the recognition of impending complete heart block in anteroseptal myocardial infarction assumes importance. To this end a review was made of the standard 12-lead electrocardiograms of the eight patients with anteroseptal infarction in whom complete heart block had been observed on the continuously recorded single lead electrocardiographic monitor tracing (Table II). In two of these patients complete heart block and death occurred with such rapidity that it was not possible to obtain a 12-lead electrocardiogram immediately preceding the onset of complete heart block. The electrocardiograms of the remaining six patients displayed the pattern of complete right bundle-branch block with wide and prominent Q waves in leads V-1 through V-4. This pattern was associated with the findings of left anterior hemiblock in three patients and with left posterior hemiblock in the remaining three.

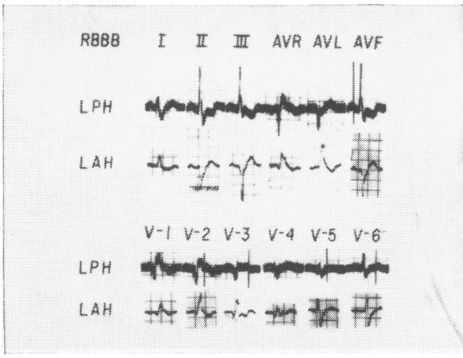

Fig. 2. Comparison of combined right bundle-branch block, Q waves in leads V-1 through V-4, and left posterior hemiblock with right bundle-branch block, Q waves in leads V-1 through V-4, and left anterior hemiblock.

In Figure 2, which illustrates the two electrocardiographic patterns observed in patients with complete heart block and anteroseptal infarction, it is apparent that the frontal axis in left posterior hemiblock is approximately $+120°$ and in left anterior hemiblock approximately $-60°$, which suggests that these hemiblocks are either complete or high degree. The Q waves in leads V-1 through V-4 are impressive; they measure at least 0.02 sec. from onset to nadir, and wider than that observed in uncomplicated hemiblock.[1]

The presence of right bundle-branch block with either left anterior or left posterior hemiblock in patients developing complete heart block in anteroseptal infarction is hardly surprising in view of the work of Watt and Pruitt,[9, 10] Pryor and Blount,[11] and Rosenbaum et al.[1]–much of which has already been presented at this conference. What remains to be determined is the specificity of these intraventricular blocks as forecasters of complete heart block.

With this goal in mind a return was made to the original 350 consecutive patients with acute myocardial infarction from which the sample of complete heart block had been drawn. The electrocardiograms of these patients were screened for complete left bundle-branch block, complete right bundle-branch block, and combinations of right bundle-branch block with left anterior or left posterior hemiblock (Table III). Left bundle-branch block occurred in approximately 5% of patients, was accompanied by a high mortality (12 of 19 patients died during their hospitalization), but could not be related to the development of

TABLE III. BUNDLE-BRANCH BLOCKS AND FASCICULAR BLOCKS OBSERVED IN 350 PATIENTS

	Number of Patients
LBBB	19
RBBB	9
RBBB, LAH	18
RBBB, LPH	9

TABLE IV. SPECIFIC ELECTROCARDIOGRAPHIC PATTERNS OBSERVED IN 350 PATIENTS

	Number of patients
RBBB, LAH, QV 1-4	9
RBBB, LPH, QV 1-4	7
Of these 16 patients	
Complete heart block	6
Cardiac arrest	3

incomplete or complete heart block in this small series. Isolated right bundle-branch block was observed relatively infrequently, did not carry an increased mortality rate in this series, and was not associated with complete heart block. The combination of right bundle-branch block and either left anterior or left posterior hemiblock was observed in 27 patients, of whom seven (approximately one in four) developed complete heart block. Right bundle-branch block combined with either left anterior or left posterior hemiblock, therefore, can serve as a clinically useful sign of impending complete heart block in anteroseptal infarction.

Thus far in my discussion with you only the abbreviated time course of a patient with acute myocardial infarction separates him from a patient with another type of heart disease and the same combination of intraventricular blocks that lead to complete heart block. There are data to suggest, however, that other differences characterize complete heart block caused by myocardial infarction. Table IV presents evidence for the view that the appearance of Q waves in leads V-1 through V-4, when combined with right bundle-branch block and either left an-

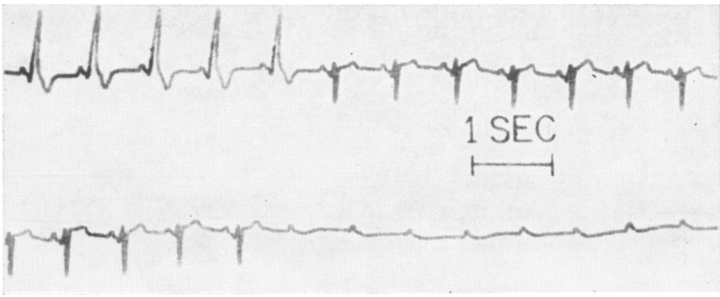

Fig. 3. An abrupt change in intraventricular conduction *(upper strip)* was followed two minutes later by sudden fatal complete heart block *(lower strip)*. The recording speed was 10 mm./sec.

terior or left posterior hemiblock, constitutes an additional parameter which increases the risk of complete heart block in anteroseptal infarction. Only 16 patients with this combination of electrocardiographic findings were observed in 350 patients with myocardial infarction. Of this total six experienced complete heart block and three others died under circumstances that were highly suspicious of the abrupt development of complete heart block. These three patients suffered cardiac arrest after transfer from a cardiac intensive care unit area. Their electrocardiograms were not monitoring at the time of onset of the arrest. The first postarrest electrocardiogram in each instance was interpreted as indicating absent ventricular depolarizations, but the records were not preserved.

It is concluded that the pattern of combined right bundle-branch block, Q waves in leads V-1 through V-4, and either left anterior or left posterior hemiblock is the most specific forecaster of impending complete heart block that emerged in this study.

Recent Clinical Controversies

Within the past year several studies[12-14] have raised questions concerning the proper treatment of the patient with acute myocardial infarction and electrocardiographic evidence of disease in both the left and right bundle-branch systems. These studies describe either the natural history of this group of patients or compare survival in treated and untreated series. The results obtained and the conclusions reached have varied greatly. The possible reasons for these differences have important clinical implications that invite discussion. In essence I should like to consider three proposals: 1) that easily-missed beat-to-beat changes in intraventricular conduction have clinical significance, 2) that conventional methods of electrocardiographic monitoring do not provide enough information for an accurate clinical appraisal, and 3) that the syndrome of acute myocardial infarction, right bundle-branch block, and left anterior or posterior hemiblock includes at least three clinical entities that differ greatly and should properly be considered separately. These proposals contain elements that could alter the composition of patients included in a series and, therefore, the results obtained.

Clinical Significance of Easily Missed Changes in Intraventricular Conduction

Figure 3 illustrates the importance of easily missed beat-to-beat changes in intraventricular conduction. In this patient with acute anteroseptal myocardial infarction, the upper tracing reveals an abrupt change in intraventricular conduction. The patient and electrocardiogram remained stable until fatal complete heart block developed two minutes later as recorded in the lower tracing. This record indicates that in the presence of acute anteroseptal infarction significant changes in intraventricular conduction can occur during the course of one cardiac cycle and precede by only a matter of minutes the development of A-V block, which also progresses over the course of one cardiac cycle from 1:1 A-V conduction to complete heart block. In two other patients we were fortunate to observe the time of onset of both the intraventricular block and complete heart block. The interval between these events was only 10 and 120 minutes respectively.

The Importance of Methods of Electrocardiographic Monitoring

The tracing in Figure 3 illustrates certain limitations in screening only one electrocardiographic lead. In this patient the rapidity of the course did not allow time to obtain a standard 12-lead electrocardiogram. Therefore the diagnosis of a specific type of conduction block could not be made. Further, since only one lead was recorded, we cannot exclude the appearance of an earlier intraventricular block that may have escaped detection but could have provided a warning of impending complete heart block. A conduction block may escape detection if the resulting alteration in the sequence of depolarization takes place in a plane that is perpendicular to the axis of the recording electrodes. Thus, for example, the development of left anterior hemiblock in some patients may not be apparent in lead V-1, and the appearance of right bundle-branch block may go unnoticed in lead V-6. Detection would be even more difficult if a slow recording speed precluded accurate measurement of QRS duration.

If electrocardiographic monitoring systems are to meet the challenge of such a rapidly evolving disease process, every cardiac cycle should be screened for left anterior and left posterior hemiblock, right bundle-branch block, and the presence of Q waves in leads V-1 through V-4. The simultaneous recording of leads III and V-1 (to screen for left hemiblock and right bundle-branch block respectively) could meet these requirements. Because prolongation of QRS duration in complete left anterior and left posterior hemiblock is only 13 and 17 msec. respectively,[1] a recording speed of 50 mm./sec. will occasionally be necessary to facilitate exact measurement. At this speed small increases of a few milliseconds in the PR interval due to impaired conduction in a solitary remaining bundle-branch or fascicle can be detected as well. These considerations lead to the recommendation that a system of simultaneous surveillance of leads III and V-1, with provision for permanent recording at speeds up to 50 mm./sec., be employed in patients prone to the development of intraventricular blocks leading to complete heart block.

Clinical Subgroups of Intraventricular Block

Within the group of patients with acute myocardial infarction, right bundle-branch block, and either left anterior or left posterior hemiblock, certain differences were noted. These observations indicated that it might be clinically useful to make a division into three subgroups: patients with 1) right bundle-branch block and left posterior hemiblock, 2) right bundle-branch block, left anterior hemiblock, and Q waves in leads V-1 through V-4 and, 3) right bundle-branch block, left anterior hemiblock, but an absent Q wave in lead V-1 through V-4.

Table V reports the outcome in the subgroup of nine patients with combined right bundle-branch block and left posterior hemiblock. There were five deaths due to shock. Complete heart block was observed in three additional patients; one died immediately and two survived. The ninth patient died from cardiac arrest under circumstances that

TABLE V. OUTCOME IN NINE PATIENTS WITH RIGHT BUNDLE-BRANCH BLOCK AND LEFT POSTERIOR HEMIBLOCK

	Number of patients
Died in shock, early	4
Died in shock, late	1
Died of complete heart block	1
Died of cardiac arrest	1
Survived complete heart block to discharge	2
Still alive	0

suggested complete heart block as a mechanism, although the electrocardiogram was not screened before the arrest. The postarrest electrocardiogram was reported to reveal absent ventricular depolarizations but was not preserved. One of the two surviving patients died suddenly four months after discharge during an episode of cardiac pain. The other died in congestive failure three years after discharge.

It is concluded that the pattern of right bundle-branch block and left posterior hemiblock in acute myocardial infarction carries a high immediate mortality due to shock. Complete heart block is very common but is not incompatible with survival. Patients with this electrocardiographic pattern exhibited either shock, complete heart block, or cardiac arrest. There were no uncomplicated myocardial infarctions in this group. Ultimately all patients died. Three years was the longest period of survival.

The remaining two subgroups contain patients with combined right bundle-branch block and left anterior hemiblock. This combination is commonly observed in older patients in the absence of acute myocardial infarction. In some patients the lesions are caused by a degenerative process and not by coronary insufficiency.[1] It is logical to assume that a few patients with chronic right bundle-branch block and left anterior hemiblock attributable to idiopathic degeneration of the cardiac skeleton will also develop an unrelated acute myocardial infarction. The course of these patients might differ from those who develop right bundle-branch block and left anterior hemiblock as a direct consequence of an acute infarction involving the intraventricular septum. Because a Q wave in lead V-1 in the presence of right bundle-branch block has long been considered a sign of infarction of the intra-

TABLE VI. COMPARISON OF THE TIME OF ONSET OF RIGHT BUNDLE-BRANCH BLOCK AND LEFT ANTERIOR HEMIBLOCK IN PATIENTS WITH AND WITHOUT Q WAVES IN LEADS V-1 THROUGH V-4

	Number of patients Q V 1-4 Yes	No
After admission	4	1
Between admission and previous ECG	2	0
Before myocardial infarction	0	4
Unknown	3	4

ventricular septum,[15] it was thought possible that this electrocardiographic finding might help to discriminate between an intraventricular block caused by an acute infarction and one that was not.

To test this hypothesis the time of onset of right bundle-branch block and left anterior hemiblock was compared with the presence or absence of Q waves in leads V-1 through V-4. Of the 18 patients with right bundle-branch block and left anterior hemiblock, nine had Q waves and nine did not. Table VI reveals that it was possible to date the onset of right bundle-branch block and left anterior hemiblock relative to the myocardial infarction in nine of 18 patients. In this group Q waves in leads V-1 through V-4 were observed when the onset of intraventricular block was simultaneous with the onset of myocardial infarction. In the absence of Q waves the block was observed to antedate the myocardial infarction in all patients but one. These findings suggest that right bundle-branch block and left anterior hemiblock generally result from the myocardial infarction when Q waves are present in leads V-1 through V-4, but may be unrelated to the myocardial infarction when Q waves are absent in these leads.

Table VII indicates that complete heart block and instances of cardiac arrest in which complete heart block was the probable mechanism were observed more frequently in the group of patients with Q waves in leads V-1 through V-4. Table VII, when compared with Table V, also indicates that immediate and long-term survival occurred more often in patients with right bundle-branch block and left anterior hemiblock than in patients with right bundle-branch block and left posterior hemiblock. Of the patients with combined right bundle-branch block and left anterior hemiblock who also experienced complete heart

TABLE VII. COMPARISON OF OUTCOME WITH AND WITHOUT Q WAVES IN LEADS V-1 THROUGH V-4 IN 18 PATIENTS WITH RIGHT BUNDLE-BRANCH BLOCK AND LEFT ANTERIOR HEMIBLOCK

	Number of patients Q V 1-4 Yes	No
Patients included	9	9
Complete heart block	3	1
Cardiac arrest	2	0
Discharged	4	6
Still alive	3	5

block, only one survived to be discharged from the hospital. He died two years later during the course of the second of two subsequent myocardial infarctions.

SUMMARY

1) In acute anteroseptal myocardial infarction complete heart block frequently develops in patients with combined right bundle-branch block, left anterior or left posterior hemiblock, and Q waves in leads V-1 through V-4.

2) In these patients complete heart block usually occurs abruptly, is preceded by Mobitz type II second degree A-V block in a minority of patients, and is customarily not preceded by first degree A-V block or the Wenckebach phenomenon.

3) The combination of right bundle-branch block and left posterior hemiblock in acute infarction carries a grave prognosis even in the absence of complete heart block.

4) The combination of right bundle-branch block and left anterior hemiblock in acute infarction carries a less grave prognosis, especially for patients who do not develop complete heart block.

5) The presence of Q waves in leads V-1 through V-4 in patients with combined right bundle-branch block and left anterior hemiblock generally indicates that the intraventricular block was produced by the myocardial infarction. Complete heart block is common in this circumstance. The absence of these Q waves indicates that the intraventricular block usually antedates the myocardial infarction and may be unrelated to it. Complete heart block is less common in this group.

REFERENCES

1. Rosenbaum, M. B., Elizari, M. V. and Lazzari, J. O.: *The Hemiblocks.* Oldsmar, Fla., Tampa Tracings, 1970.
2. Stock, R. J. and Macken, D. L.: Observations on heart block during continuous electrocardiographic monitoring in myocardial infarction. *Circulation 38*:993, 1968.
3. Master, A. M., Dack, S. and Jaffe, H. L.: Partial and complete heart block in acute coronary artery occlusion. *Amer. J. Med. Sci. 196*:513, 1938.
4. Master, A. M., Dack, S. and Jaffe, H. L.: Bundle branch and intraventricular block in acute coronary artery occlusion. *Amer. Heart J. 16*:283, 1938.
5. Cohen, D. B., Doctor, L. and Pick, A.: Significance of atrioventricular block complicating acute myocardial infarction. *Amer. Heart J. 55*:215, 1958.
6. Gilchrist, A. R.: Clinical aspects of high grade heart block. *Scot. Med. J. 3*:53, 1958.
7. Blondeau, M., Rizzon, P. and Lenègre, J.: Les troubles de la conduction auriculo-ventriculaire dans l'infarctus myocardique récent: I. Étude clinique. *Arch. Mal. Coeur 54*:1092, 1961.
8. Blondeau, M., Rizzon, P. and Lenègre, J.: Les troubles de la conduction auriculo-ventriculaire dans l'infarctus myocardique récent II. Étude anatomique. *Arch. Mal. Coeur 54*:1104, 1961.
9. Watt, T. B., Jr. and Pruitt, R. D.: Character, cause, and consequence of combined left axis deviation and right bundle branch block in human electrocardiograms. *Amer. Heart J. 77*:460, 1969.
10. Watt, T. B., Jr. and Pruitt, R. D.: Left posterior fascicular block in canine and primate hearts: An electrocardiographic study. *Circulation 40*:677, 1969.
11. Pryor, R. and Blount, S. G., Jr.: The clinical significance of true left axis deviation: left intraventricular blocks. *Amer. Heart J. 72*:391, 1966.
12. Godman, M., Lassers, B. and Julian, D.: Complete bundle branch block complicating acute myocardial infarction. *New Eng. J. Med. 282*:237, 1970.
13. Atkins, J. M., Leshin, S. J., Blomquist, G. and Mullins, C. B.: Prognosis of right bundle branch block and left anterior hemiblock: A new indication for permanent pacing. *Amer. J. Cardiol. 26*:624, 1970.
14. Scanlon, P. J., Pryor, R. and Blount, S. G.: Right bundle branch block associated with left superior or inferior intraventricular block associated with acute myocardial infarction. *Circulation 52*:1135, 1970.
15. Myers, G. B., Klein, H. A. and Hiratzka, T.: IV Correlation of electrocardiographic and pathologic findings in infarction of the intraventricular septum and right ventricle. *Amer. Heart J. 37*: 720, 1949.